10/523988

Rec'd PCT/PTO 09 FEB 2005

INVESTOR IN PEOPLE

The Patent Office

PATENTS • DESIGNS • COPYRIGHT • TRADE MARKS

CHARTER MARK

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 09 SEP 2003
WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed *A. Evans*

Dated 14 August 2003

Patents Form 1/77

nts Act 1977
e 16)

THE PATENT OFFICE
0 8 AUG 2002
RECEIVED BY HAND

The Patent Office

0 8 AUG 2002

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office
Cardiff Road
Newport
Gwent NP9 1RH

1.	**Your reference**	406.78827
2.	**Patent application number** *(The Patent Office will fill in this part)*	0218452.1
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Depak Lal 3, Home Ground Cricklade Wiltshire SN6 6JG 09AUG02 E739687-1 D00027 P01/7700 0.00-0218452.1
	Patents ADP number *(if you know it)*	8442469001
	If the applicant is a corporate body, give country/state of incorporation	
4.	**Title of the invention**	Energy Consumption Monitoring
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	**If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and** *(if you know it)* **the or each application number**			

		Number of earlier application	Date of filing *(day / month / year)*
7.	**If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application**		

8.	**Is a statement of inventorship and of right to grant of a patent required in support of this request?** *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	No

Patents Form 1/77

Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	14
Claim*(s)*	
Abstract	
Drawing*(s)*	8 + 8 //1

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Date 8 August 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Michael J. Butler
020 7206 0600

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*
b) *Write your answers in capital letters using black ink or you may type them.*
c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s) of the form. Any continuation sheet should be attached to this form.*
d) *If you have answered 'Yes', Patents Form 7/77 will need to be filed.*
e) *Once you have filled in the form you must remember to sign and date it.*
f) *For details of the fee and ways to pay please contact the Patent Office.*

G:\SECDATA\MJB\Depaklal\78827.doc

Energy Consumption Monitoring

This invention relates to the monitoring of energy consumption, such as gas or electricity consumption on a network such as the electricity National Grid. in the United Kingdom.

In many countries such as England, electricity market trading arrangements are based on a commodity market model in which there are producers (electricity generators) and retailers (who trade in electricity between the producers and end consumers). The producers and retailers (traders) are required to know what their physical requirements are for electricity ahead of actual production and consumption. The traders are then expected to take contractual positions to cover their requirements. Any difference between the contractual positions for physical energy and the actual energy produced or consumed is penalised.

In the electricity market there is a constant drive to balance supply and demand on an instant-by-instant basis. The activity is a 24-hour a day and seven day a week process because, for all practical purposes, it is deemed that volume electricity cannot be stored at an economic cost. It must be produced at the time it is to be consumed. Consequently, the production of electricity is balanced with actual demand on a real-time basis.

To define a consistent period over which the traders in the market can settle their accounts, in the English electricity market there is a Settlement Period of duration 30 minutes. There are 48 such Settlement Periods in a standard day. For each trader in the market, the contractual position for each Settlement Period must be consistent with the actual physical position if penalties are to be avoided. The settlement period for the UK gas market is currently 24 hours.

The cost of balancing the system is based on the bids and offers accepted by the Grid Operator from the traders active in the balancing market to either provide more energy or take more energy from the Supergrid. The cost incurred of balancing the system forms the basis of penalties to those parties out of balance (where physical position varies from notified contractual position).

Typically, the producers of energy are in a position of strength in the electricity and gas markets. They deliver the volume of contracted energy at the appropriate time. There are occasional problems associated with engineering failures of plant and also the unreliability of output of, for example, wind-powered generators that compromise the ability of producers to meet contractual positions. However, in general the producers deliver on their contracts because the output is controllable.

The main problem is on the consumption side of the market. Consumers , in most cases, demand electricity (and gas) at a time of their choosing. The costs of wholesale market penalties on the retailer are therefore factored into the price of the sales contract between the retailer and the consumer.

Consumer demand fluctuates quite widely for the individual consumer. A single household will consume energy in a way that is largely unpredictable. On a population basis, the demand is more predictable but there is still substantial and material room for error. The major factors affecting demand are environmental factors such as weather, daylight and also TV pickup. It is extremely difficult for retailers to accurately predict in advance what the actual demand of consumers will be for a particular Settlement Period. This leaves retailers buying either too little or too much energy in the market and then suffering the consequential penalties. In general retailers tend to go long in the market to ensure that they have sufficient energy to cover their customer demands as this is the only sensible risk management strategy available to them at this time.

In trading terms, the problem that retailers cannot resolve is that the physical energy consumed can (practically) only be known post-consumption. Yet purchase contracts need to be agreed well in advance of consumption. The result of this structural feature of the market is that currently retailers are mainly passive players in the market that take the consequences of imbalances and the producers of energy react to meet the requirements to physically balance the system. It follows that retailers would benefit from access to more financially efficient and effective tools that allow them to manage the risk and consequences of being out of balance instead of simply going long.

Whilst analysis of past consumption patterns, weather forecasts, television schedules and so forth can enable electricity retailers to predict consumption to a certain extent, there is a need to monitor real time consumption. If there is a rise or drop in consumption compared to predicted patterns, this may indicate that following predictions may need to be altered. For example, there may be an unexpected news event which will result in people stopping their normal activities to watch the television.

In the United Kingdom electricity market, there is the concept of "Gate Closure". The market for trading physical energy is closed a predetermined period ahead of energy consumption, for example 3.5 hours. The present system of monitoring total consumption is based on a summation of grid meter readings on a two minute cycle, using data that is on average one minute old. Previously this has been adequate for engineering balancing purposes but it is not necessarily good enough for trading. In this specification there is disclosed a method by which traders can take into account of probable changes in demand which appear likely to arise even after Gate Closure. One aspect of the present invention concerns an improved system for monitoring consumption, that will provide data that is more up to date.

Thus, viewed from one aspect of the present invention there is provided a method of monitoring energy consumption on a network provided with a plurality of consumption meters, in which readings are received from the meters and summed (meter reading summation process) to provide a total consumption figure at intervals, characterised in that there are stored the individual meter readings that were received and used to calculate a total T(t), and in that when an updated reading from a particular meter has been received there is calculated a new total T(t+1) which is the sum of the previously

stored individual meter readings used to calculate the previous total T(t), less the previously stored individual meter reading for that particular meter, plus the updated reading for that particular meter.

Thus, as an updated meter reading is received, a new total may be calculated immediately. This by contrast to existing systems in which a new total is calculated only after all updated readings have been received, over a period of e.g. two minutes.

The new total could be calculated in accordance with a trigger as each updated reading is received, or the system could be polled to calculate new totals at intervals which are substantially shorter than the time required to receive updated readings from all of the meters, such as at one second intervals.

The data manipulated and produced could be actual consumption figures, raw data from meters, or anything else which is representative of consumption.

The figures received may be used for any analytical purposes. However, they are of particular use in the implementation of a process which enables the retailers of energy to reduce the economic effect of imbalances if they detect, from updated data, that there are likely to be such imbalances.

The solution set out below provides the means for retailers to manage the financial consequences of imbalances. A basic point is that physical balancing is a real-time activity conducted by the system operator (e.g. the controller of the UK National Grid) and physical balancing will occur regardless of the actions of retailers. The real issue is to manage the financial consequences of being out of balance. The solution is to provide financial hedging tools within a framework that reflects the divergent perspectives of producers and retailers.

The retailer should take account of whatever information on demand is available to forward predict the retailer's own customer demand and to then buy financial options to manage the financial consequences of errors in the prediction. The prediction tool for retailers suggested in this specification is optional. However, the particular tool suggested in this specification has advantages over other methods when it comes to hedging activities. The method described here using real-time actual demand is likely to be more accurate because there is significantly less reliance on historic correlations (of dubious accuracy that apply over very coarse time scales when the market is working on 30-minute Settlement Periods). This aspect of the invention (which gives an improved result if the previously stated meter reading summation process is used) will provide market information to retailers that will be useful in trading.

The probabilistic nature of forecasting accuracy highlights why physical balancing by retailers is of limited value and it must be supplemented by financial hedging if the retailer is to manage business exposure. The importance of physical forecasting is greatly reduced if financial hedging tools can be used to manage the consequences of errors. The use of financial hedging instruments allows traders to continue to trade post Gate Closure

and right up to energy consumption. The physical position remains unchanged but the financial consequences of uncertainties can still be actively managed.

The producers and retailers are active in an asymmetric market. The asymmetry arises where the financial consequences for producers are on a genset by genset basis in a bilateral contract with the system operator in balancing the market. Meanwhile the aggregate service provided by all traders in the balancing market is used to calculate the imbalance penalties on a national basis so that the financial consequences of imbalances for retailers are the averaged result of the activity of all the players in the market. What is required is a common reference framework for producers and retailers (reconciling the differing perspectives) to enable both parties to trade hedging contracts across the market in a risk managed way with a common basis for valuations. An index would provide this reference framework and the details of such an index are provided below. This index is another aspect of the invention that leads to an enhanced result for trading purposes by the use of the meter reading summation process.

An outline of the process is as follows.

There is historic data on the demand in each Settlement Period going back many years. Often demand is classified into that energy consumed in a working day, non-working day and season.

It is proposed that the average demand over the past (say) 5 years is calculated on the basis of working day and non-working day for each month of the year. Some allowance may have to be made for clock change dates and also public holidays in the calculation of historic average demand.

It would also be useful to inflate the calculated average demand by demand inflation. Typically, national electricity demand in the UK is increasing at 1.6% pa (long run average rate) through economic growth. However actual growth in demand varies on an annual basis depending on the actual economic activity and the economic cycle. Application of actual demand inflation can be used to bring the calculated average demand up-to-date.

To a first approximation, retailers will be purchasing energy on the basis of historic data to estimate the demand of their customers. Variations in actual demand relative to historic data are an indication of how over or under contracted a retailer might be in the market. A retailer therefore needs to estimate how his demand is likely to change in the near future relative to the historic averages as an estimate of potential imbalances (actual physical demand versus contractual position).

The national demand ("NDspot") is known at an instant in time by the summation of the energy measurements on the national grid. Whilst the meters on the Supergrid do not provide an indication of all the energy consumed (for example, embedded generation is not reflected in meter readings, the reading give a good indication of the variation in

demand relative to historic demand and also in the change in the demand profile during the day. It is the variation that matters in this risk management solution.

The NDspot readings need to be translated into 30-minute readings to allow the data to be compared with historic demand data, to be useful on a Settlement Period basis and also to capture a degree of smoothing.

A retailer needs to take a view on how his own demand (for his own customers) is correlated to national demand. Experience and historic data will provide an indication of how much demand for a particular period compares. Using the grid demand data, the retailer will then be able to estimate his own demand.

The retailer also needs to take a view of how the variation in the national demand (ND) for a given Settlement Period varies from historic average to predict what the variation will be in national demand at some Settlement Period later in the day.

Combining the correlation in own demand to ND forecasts and the correlation between ND now and the forecast ND, the retailer will be able to predict own demand in the future from current ND.

The requirement is therefore to correlate activity to real-time ND and to publish an index that provides the retailers will information on the variation in ND. The index will be based on the difference (D*).

D* = The difference between current National Demand (ND) over a 30-minute period and historic average demand (HD) over the same 30-minute period.

The magnitude of D* provides an indication to both producers and retailers of the size of the potential system imbalance; the likely consequent cost of addressing the imbalance; and the likely consequent value of services used in addressing the imbalance.

The producers and retailers can trade options to hedge the financial exposure. The parties can trade call and put options on the price of imbalances. In the English market the price of imbalances is denoted System Buy Price (SBP) and System Sell Price (SSP). If S is the strike price, a call option for SBP might payout £(S-SBP) for a standardise contract volume of (say) 1MWh. A producer and retailer may trade many of these contracts to get the appropriate volumetric level (MWh) of contracts to cover the physical volume of energy at risk. Similar contracts can be constructed for puts and SSP hedges.

Since the probability of getting the physical forecast absolutely right is significantly less than 100%, the retailer can more constructively manage his cost of being out of balance through financial hedging, both pre and post Gate Closure.

The volumes of options contracts offered by producers (in relation to generator units – "gensets" - that are expected to be active in the balancing process for a particular

Settlement Period) will define to some degree the producers desired market share in the balancing market (if the producer wants a hedged position).

Further sales of such options contracts in relation to very high priced marginal gensets that are not expected to play a part in balancing provide a means of rewarding gensets that provide a service with regard to system security.

The result is that both sides of the market have price and volume certainty and trading across the market will provide a mechanism for price discovery. In addition system security is enhanced.

Once the spot market in options is developed, there is another market in consequential derivatives that would follow. For example, for a particular Settlement Period, there could be an option traded to cover the price exposure for the working days (or non-working days) in November This kind of product would be particularly useful for those smaller players who do not want to be actively managing their positions on a real time basis; they really want a simple product that works over a long period of time.

Traders can constructively buy and sell physical energy up to Gate Closure and register the energy in their contractual accounts. Post Gate Closure, the only option is to deal with the financial consequences of imbalances. At Gate Closure, a more refined index (D**) might also be introduced.

$$D^{**} = D^* - D^*(\text{at Gate Closure})$$

D** is reflecting post Gate Closure activity. The assumption is that pre Gate Closure, the publication of the D* index will lead traders to take physical action in the market. The D** index reflects the post Gate Closure variations.

With options, the financial outlay is the option premium. With physical energy, the purchase outlay is much higher and the trader still does not know whether the action will put the trader back into balance in either direction (could be out of balance in the opposite direction if the trader goes too far). Given the inherent uncertainty in forecasting, retailers will probably do some simple pre Gate Closure physical balancing (with some financial hedging) several hours ahead of physical consumption and then increasingly use financial hedging as the time of energy consumption approaches. This takes the stress out of forecasting accuracy.

Financial options also have another useful attribute. Traders can take a portfolio position on prices and volumes covered so that they can spread their position. With a range of strike prices and a range of volumes, traders can fine-tune their risk position to take account of their appetite for risk. Delta hedging and rebalancing strategies will be the normal practise for the traders.

Much of the detail described above can be refined so that the model is not just based on correlating demand and demand variances to ND. The market could also provide data on a regional basis since the metering on the grid exists to do this.

The methods and systems described above and below for dealing in options are inventive in their own right, regardless of the method chosen to monitor usage, i.e. regardless of whether the preferred system is used or not. Thus, further aspects of the invention relate to such methods and systems. By way of example only, viewed from another aspect of the invention there is provided a method of reducing the financial effects of imbalances in a system in which retailers contract for the supply of energy from energy producers, the method comprising the steps of forecasting the retailer's own demand error; using a commonly applicable index by producers and retailers to give an indication of the degree of imbalance in the market; and using financial derivatives to hedge the financial consequences of imbalances. Also by way of example, viewed from another aspect of the invention, there is provided a data processing system for analysing energy usage on a network including a number of energy sources and a number of energy consumers, including meters on the network which measure energy usage on the network throughout a day; wherein a database is provided which stores historical energy usage data so as to provide, for predetermined intervals during a specified day of the year, average historical energy usage values; wherein for a given current one of those predetermined intervals during a day of the year, data from the meters provides a current energy usage value on the network; and wherein an index is produced which indicates the difference between the average historical energy usage value for that interval on that day of the year, and the current energy usage value for that interval

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a representation showing typical daily national demand for electricity;

Figure 2 is a diagram illustrating forward prediction of demand;

Figure 3 illustrates integration of spot readings of national demand;

Figure 4 also illustrates integration of spot readings of national demand;

Figure 5 illustrates financial hedging;

Figure 6 illustrates how trading evolves over a 24 hour period;

Figure 7 illustrates the merit order of plant; and

Figure 8 illustrates the uses of the index D*.

The solution to the markets problems has three elements: the forecasting of the retailers own demand error; the use of a commonly applicable index by producers and retailers

that gives a measure of imbalance in the market; and the use of financial derivatives that hedge the financial consequences of imbalances.

There are two steps in the demand forecasting process.

Firstly, the retailer needs to have information on how real-time national demand (ND) is varying relative to historic averages (Fig. 1). Through this process, the retailer will be able to take account of those (environmental or external) factors that are affecting consumer behaviour. The retailer can then more accurately predict what ND might be in the near future (say) a few hours away. The resultant prediction will have an error distribution associated with it. Secondly, the retailer needs to correlate 'own' historic demand with ND. This reflects the retailer's specific customer portfolio. Again the resultant answer will have an error distribution associated with it.

Combining these two forecasts and the associated error distributions will allow a retailer to forecast his own demand in the future using the current ND data (Fig. 2). There will be a probability distribution of how good the resultant forecast is. The probability distribution will provide the retailer with information on the balance between physical and financial hedging. The prediction process can also be rationalised on a regional) basis so that a supplier can make more accurate estimates of own demand

The creation of an historic average of demand using several years of data (using Settlement and/or real-time metering data) provides a base level against which activities will be measured. The average demands will be calculated for each Settlement Period for months of the year, classified into working day and non-working day, etc. and could take account of a structure used by a trade body of the electricity supply industry in constructing load profiles.

If (say) 5 years of historic data are used and simply averaged, the resultant average will really reflect the demand 2.5 years ago. An inflator needs to be applied to take account of inflation (or deflation) in the demand for energy over the past 2.5 years. The result will be an average that has been brought up-to-date. The net result is an estimate of the expected normal demand for a particular classification of Settlement Period.

On both the entry and exit points on a national electricity supply grid, real-time energy meters measure energy flows. The grid operator uses this data to mange the power flows on a real time basis. The grid operator therefore has real-time data on energy demand. The data is not as accurate as settlement metering. However, for the solution proposed it is the relative changes in energy flows that are of interest.

The grid operator reads the real-time meters every two of minutes (or so). The reading are summed and the result forms an estimate of NDspot (MW). The current process uses data that is on average one minute old in providing NDspot because meter readings are collected and stored until all the meter readings are in before NDspot is calculated. In the system in accordance with one aspect of the invention, as a meter reading is collected

from Meter M3 (say), the previous reading of meter M3 should be immediately substituted in ND by the new reading for M3. If this is done for all meters on a continuous basis as and when the meter reading arrives, the value of NDspot will be based on the most up-to-date information available. This will greatly enhance the accuracy of the measured demand and enhance the liquidity in the trading market.

The following is one proposed way in which NDspot will be calculated.

MT_t	is the total metered volume at time, t
$MT_{t+\Delta t}$	is the total metered volume at a later time, $t + \Delta t$
mx_i	is the ith meter reading for meter x. It can have a positive or negative value.

Assume a Base Point at (say) 03:00 hours each day.

$$MT_0 = \Sigma (m1_0 + m2_0 + m3_0 + m4_0 + m5_0 + m6_0 + m7_0 + \ldots)$$

As time moves forward, the total metered volume becomes MT_t where t designates a point in time.

As each subsequent meter reading arrives, the old meter reading is substituted by the new meter reading.

$$MT_{t+\Delta t} = MT_t - mx_{i-1} + mx_i$$

This algorithm works whether the meter readings arrive sequentially or in some random sequence. In each case all available data is used as soon as it becomes available. This is an improvement on the existing process that carried out a summation of all readings on a two-minute cycle using data that is on average 1 minute old.

Because of rounding errors that will invariably creep into the substitution process, it is recommended that a quiet point in the 24-hour day be used to re-establish a base point of readings (so that errors are not compounded into perpetuity). The most appropriate time for this base point might be sometime between 01.00 to 05.00 when demand tends to be flat and the market extremely quiet.

As each meter reading arrives and the value of NDspot is recomputed, the result needs to be turned into something that the market can use practically. What is required is a value of ND that covers 30-minutes. As each new value of NDspot is recomputed, all the NDspot values over the previous 30-minutes should be integrated to give an estimate of total demand over a 30-minute period. This is not a Settlement Period of 30-minutes, but a rolling 30-minute period (Figs. 3 and 4).

As each value of ND is calculated for a rolling 30-minute period, a corresponding value of historic demand needs to be calculated. The value of ND will probably straddle two Settlement Periods. For example (Fig. 3) if the latest ND figure covers 3 minutes in Settlement Period SP35 and 27minutes of SP36, then the comparable historic demand could be based on

$$HD^* = 10\% \text{ of } HD(35) + 90\% \text{ of } HD(36)$$

The value of 30-minute ND can then be compared with historic demand. The difference is D*.

$$D^* = ND - HD^*$$

The value of ND at Gate Closure should be subtracted from the subsequent values of ND. The result will give an indication of variation from ND post Gate Closure.

$$D^{**} = D^* - D^*(\text{at Gate Closure})$$

The value of D* will influence the volume and price of traded options designed to hedge SBP and SSP (Fig. 5). As the value of D* changes with time, so the traders will continually refine their positions in the market.

The following are some basic option structure examples. The assumption is that S is the option strike price, and all options are exchange traded and therefore standardised in size to say 1MWh.

Call Option payout = $SBP(X) - S(X)$ where $SBP(X) - S(X) > 0$

Put Option payout = $S(X) - SBP(X)$ where $S(X) - SBP(X) > 0$

Call Option payout = $SSP(X) - S(X)$ where $SSP(X) - S(X) > 0$

Call Option payout = $S(X) - SSP(X)$ where $S(X) - SSP(X) > 0$

More complex options would evolve in due course covering multiple Settlement Periods e.g. all overnight Settlement Periods in a month or all Settlement Periods 35 for working days in a particular month. Other complex options such as bull and bear or spark spreads would also evolve.

The market might also want hedges that are directly related to the value of D* and D**. Similar option structures can be developed for these indexes. An analogy with FTSE100 options would provide a useful structure.

Figure 6 schematically shows how trading is expected to evolve through a typical 24 hour period leading up to a particular Settlement Period. Early in the 24 hour period and right up to Gate Closure, there will be a mixture of physical purchases of electricity to balance positions and also some financial. Post Gate closure only financial trades will be of

practical value. In Delta hedging, the financial volumes would be expected to be vastly greater and they would outstrip physical trades at all times by perhaps a factor of 4.

Some specific scenarios will now be discussed by way of example.

In a first scenario, a cold front moves in off the Atlantic The retailer is expecting to sell 100MWh of electricity in a particular Settlement period under normal conditions and the retailer has already procured this volume of physical electricity. Now at t - 15 hours, the demand for electricity is expected to rise because of the cold front.

At this stage, it is unknown whether demand will increase by 10 or 50 MWh but the current expectation is for 30MWh based on empirical forecasts and information on D*. The retailer is Delta hedging. The retailer is short 30MWh physical (at £20/MWh) and buys (perhaps) 120MW (x4) of SBP call options (average premium paid might be £0.5/MWh) of various strike prices and various volumes. On the other hand the retailer might buy 30 MWh physical and then consider the probability distribution of errors around his new physical position. He could then trade SBP and SSP options to hedge the risk of errors arising from being long or short. . The actual volume of options procured will be determined by the quantitative analysis of the risks and the strategy employed by the retailer.

The producer will be the seller of the physical energy and the options (in the first instance). The financial options will cover a range of gensets and a range of volumes and prices.

At a time t – 14 hours, the demand expectation has changed again. Both the retailers and producers will rebalance the physical and financial options books to take account of the latest information. There will be an on-going rebalancing process all the way to Gate Closure. The price (and practical value) in the market of the physical energy and the associated financial options will change (higher or lower) incrementally in the market with time.

After Gate Closure and up to physical consumption of energy, only financial options can be traded. In this period (the balancing market), the grid operator is bilaterally managing the physical position energy with producers to balance the system. If a producer has sold a particular volume of options at a particular average strike price, the producer will aspire to fulfil the complementary physical position in the balancing market with the grid operator by using a range of gensets to get the volume and the average price. If the producer achieves this result, then the producer has a hedged position.

SBP and SSP (£/MWh) are known very soon after the physical energy has been consumed in a Settlement Period (in fact with a couple of hours). Assume that SBP out-turns at £40/MWh and SSP is £10/MWh. For those SBP call options purchased by the retailer at a strike price (S) less than £40/MWh, the options have some financial value and they are exercised to yield £(40-S)/MWh to the retailer. The converse is true for SSP options.

The producer, as the writer of a call option, pays out to the retailer for those call options at strike prices below SBP. Those call options at strike prices above SBP provide an income to marginal high priced gensets and they are effectively being rewarded for providing system security (insurance for the system).

In a second scenario, an international football match looks like going in to extra time. The retailer is expecting to sell 100MWh of electricity in a particular Settlement period under normal conditions and the retailer has already procured this volume of physical electricity. The retailer knows that there is a real possibility of increased demand because of the TV pickup. How does the retailer hedge this risk? At t– 1 hour, the retailer is beyond Gate Closure.

At this stage, it is unknown whether demand will increase by 10 or 50 MWh but the current expectation is for 30MWh if the game goes to extra time. The retailer is Delta hedging. The retailer trades an appropriate volume of both SBP options (average premium paid might be £0.5/MWh) of various strike prices and various volumes and SSP options. The actual volume of options procured will be determined by the quantitative analysis of the risks and the strategy employed by the retailer.

The producer will be the seller of the physical energy and the options (in the first instance). The financial options will cover a range of gensets and a range of volumes and prices.

At a time t – 5 minutes, the demand expectation is more accurate. Both the retailers and producers will rebalance financial options books to take account of the latest information. There will be an on-going rebalancing process all the way to actual consumption.

In the proposed market solution, there is no reason why trading could not continue even through the Settlement Period of interest. Options trading is of practical and commercial benefit up to the point where SBP and SSP are publicly known. What this means is that actual real time trading of SBP and SSP options can happen in tandem with actual real-time consumption of electricity.

The D* index will provide a measure of the magnitude of the imbalance. In the electricity industry, there is what is known as a 'merit order of plant' (industry terminology). There is common knowledge of the relative price and cost of individual gensets available for balancing right across the market. The merit order stacks the plant so that the lowest cost plant runs first and successively more expensive plant is called on to meet changes in demand (the merit order of generation bids will also include bids from the demand side of the market to reduce demand). There will also be a merit order of bids to reduce generation (and increase demand). As the magnitude of D* increases (positive and negative), the system operator (NGC) will call on successively more expensive bids in the merit order to correct the imbalances. All the players can estimate which genset will be called upon to fulfil the requirements of correcting imbalances. Whilst this is not

absolutely correct, there is sufficient data for all the players to trade imbalance penalties. Once the market matures and becomes more organised, then the market price will become more transparent and the merit order will become less relevant. The D* index will become the benchmark against which all the players correlate prices.

A typical market index is designed to provide a common market indicator along a common marketperspective. D* is a market index that is designed to solve the problems of orthogonal market perspectives. For example, the producers are trying to hedge their activities (price and volume) in the physical balancing market for each of their gensets. However the retailers are hedging SBP and SSP that are the result of the average of all the activities of all the players in the market. D* provides a common framework for both types of market participant and so both parties can then trade hedges (options) across the market.

The merit order data will enable players to estimate price and volume of options. By applying the theory under-pinning Delta hedging and standard quantitative tools such as Monte Carlo simulation retailers will be able to calculate the volume of hedging required and the value/price of the options under various scenarios.

The volume of options purchased by the retailer will reflect the retailer's appetite for risk (on physical imbalances and system security) and the magnitude of his expected exposure in the market. The producers will do similar calculations to value the balancing service. The volume of options sold by each producer will reflect expected physical volume sold into the balancing market plus the additional volume of service provided to risk adverse retailers in terms of the system security service. Through this process, the producer is signalling his market share aspirations in the balancing market and system security market assuming that the producer is taking a risk-balanced position where the volume and price of financial options traded represents the producers anticipated physical position. If the producer does not take a balanced position, then the producer is acting as a market speculator.

It is worth pointing out that producers will endeavour to get the price\ volume hedge correct for each Settlement Period. However what the producers actually need to do is recover the appropriate volume and price over, say, a year. As a result, both producers and retailers get a less volatile price market and the market is 'smoothed'. Both parties can therefore take a risk-managed position which is the main driver behind trading.

In the first instance (first approximation), producers are the providers of balancing services and retailers are the passive consumers of balancing services. What this means is that the main writers of options will be the producers and the main buyers will be retailers. As the market matures, this will become an increasingly simplistic description.

The options traded can cover individual Settlement Periods of different blocks of time. There are two classes of options that this solution covers. The first is the conventional type of financial option that is directly hedging SBP and SSP prices. The second is an option based on trading the D* index itself. If D* is greater than or less than a particular

value, then that triggers a payment from the option writer to the option holder. These are the key traded products.

Exotic options can cover a whole range of complex options products that combine several simple products into one product. There are other derived indexes that spin out of D*.

In use of the system, the value of D* will be broadcast. Retailers and producers will trade physical energy to take account of the information provided by D* on the potential for imbalances.

At the same time, both types of player will trade financial options in parallel with the physical trades. The need to trade financial options arises from the need to manage risk on price movements and Delta hedging is a standard technique. As D* changes, the potential price of SBP and SSP changes. If Delta hedging is applied, then it is probable that the volume of financial options traded could be several times (say 4 times) the volume of physical energy at risk in the balancing market.

The value of D* will change with time. If Delta hedging is followed, the traders will have to continuously rebalance the physical and options positions. The parameter Gamma (a standard term in commodity trading) determines how often rebalancing should be carried out. Rebalancing involves selling the current position and taking a new position in the market.

D* will change continuously and so there should be constant rebalancing of the traders position.

The traders will have to hedge both SBP and SSP prices if risk is to be fully managed.

G:\SECDATA\MJB\Depaklal\Spec.doc

Fig. 1: National Demand

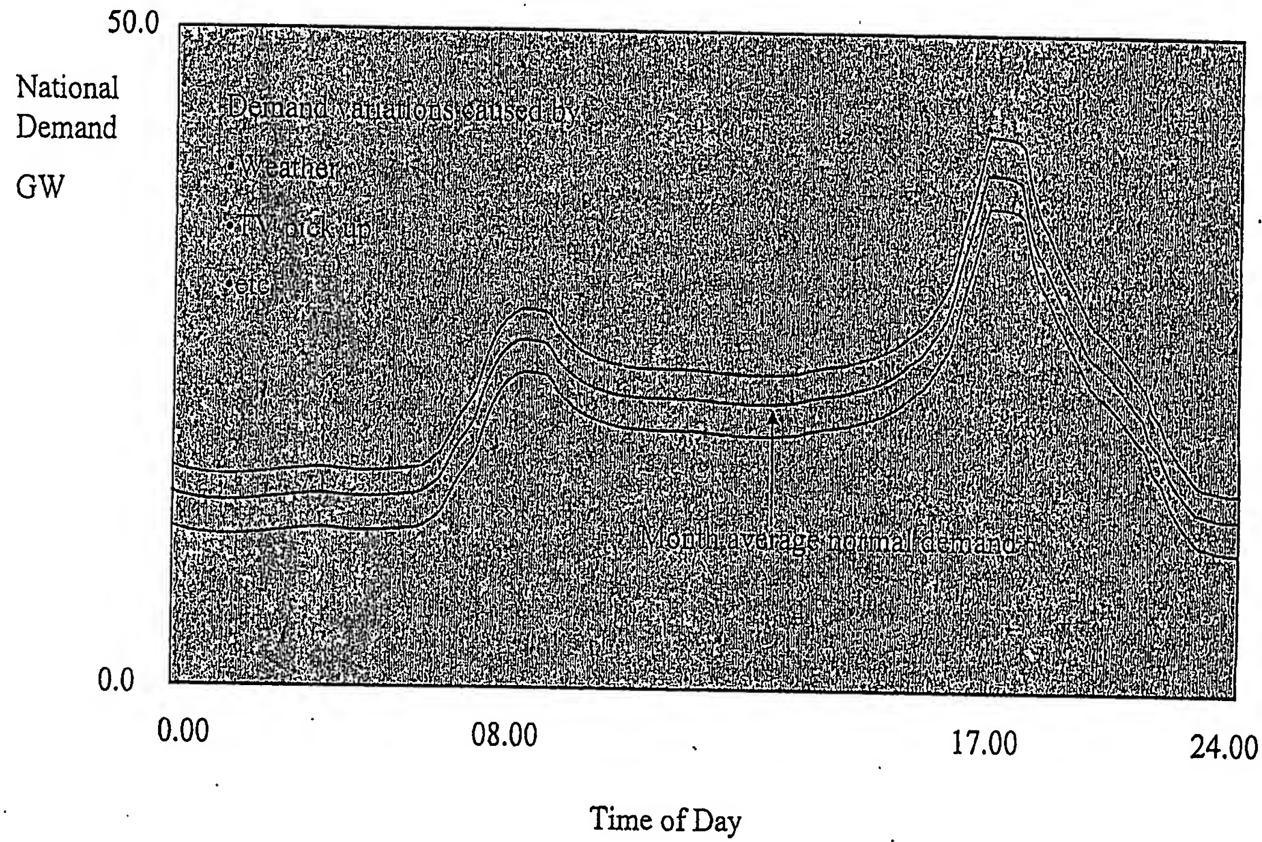


Fig. 2: Forward prediction of National Demand

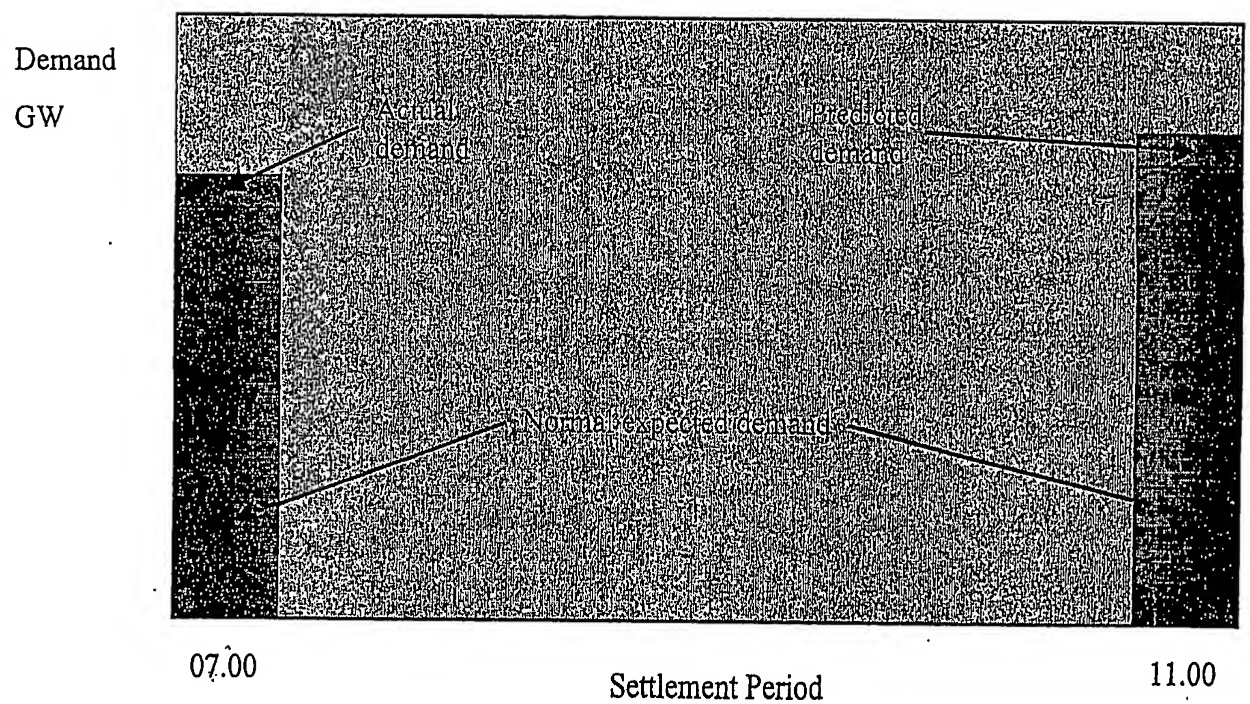


Fig. 3: NDspot Integration - I

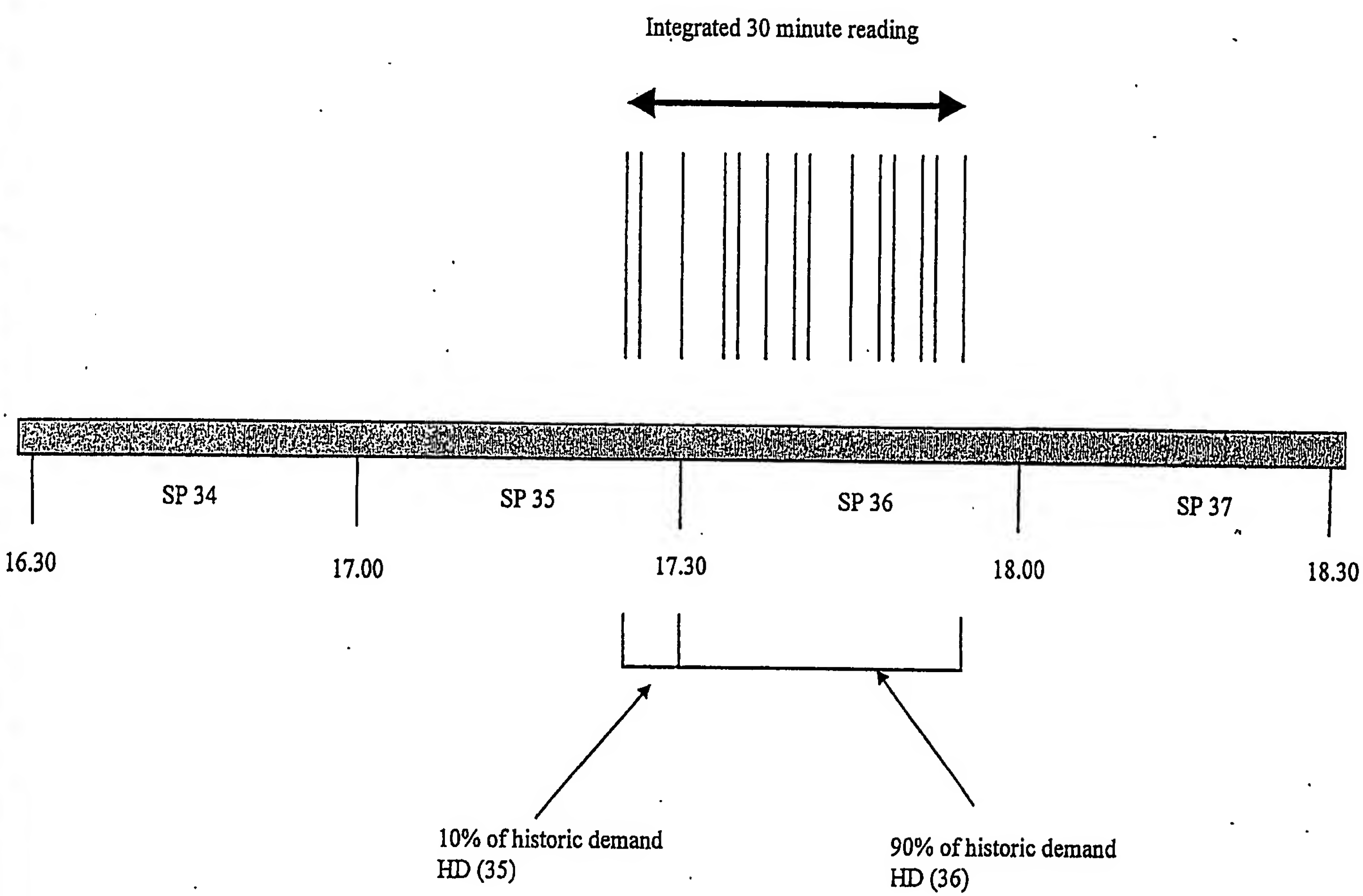
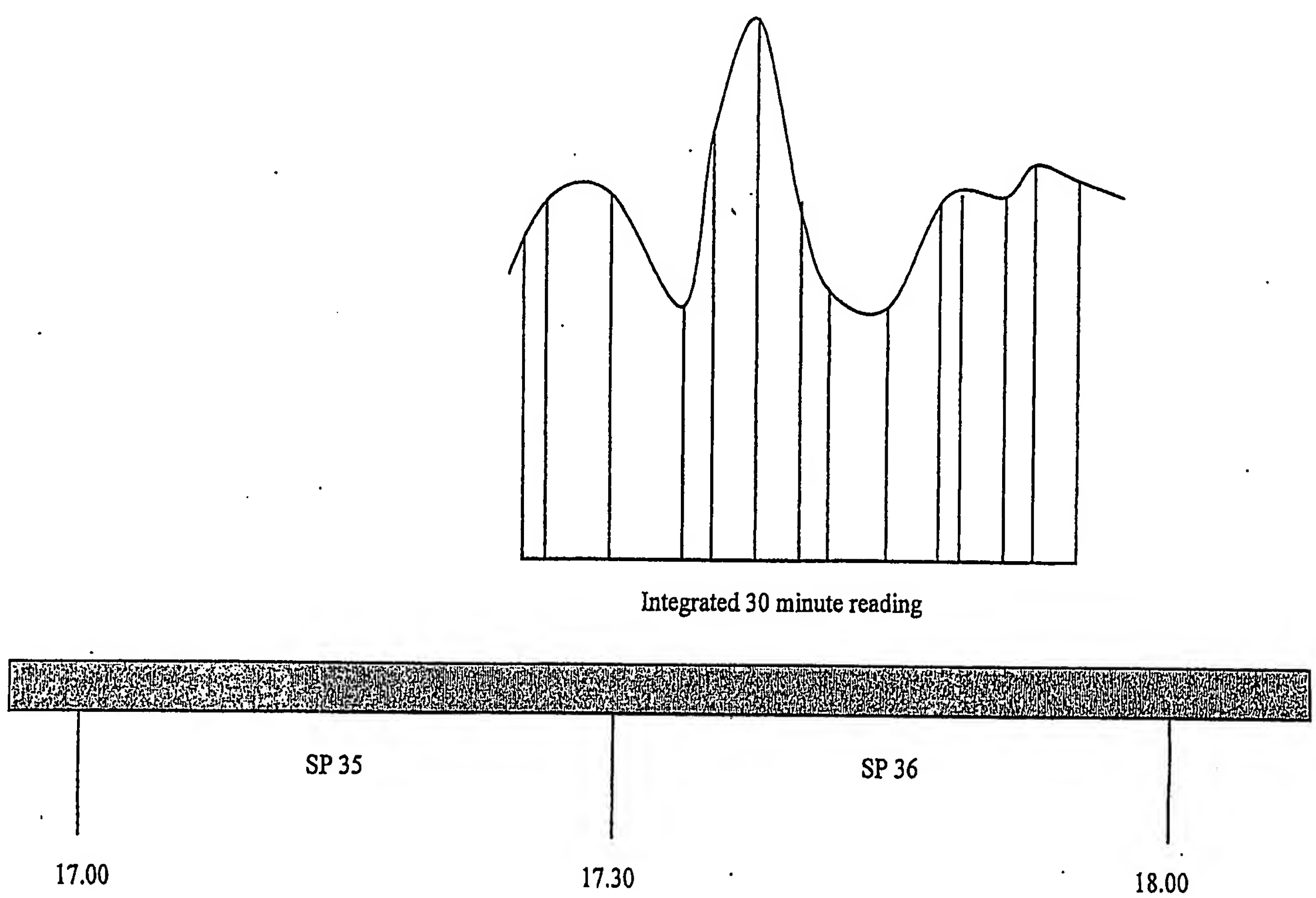
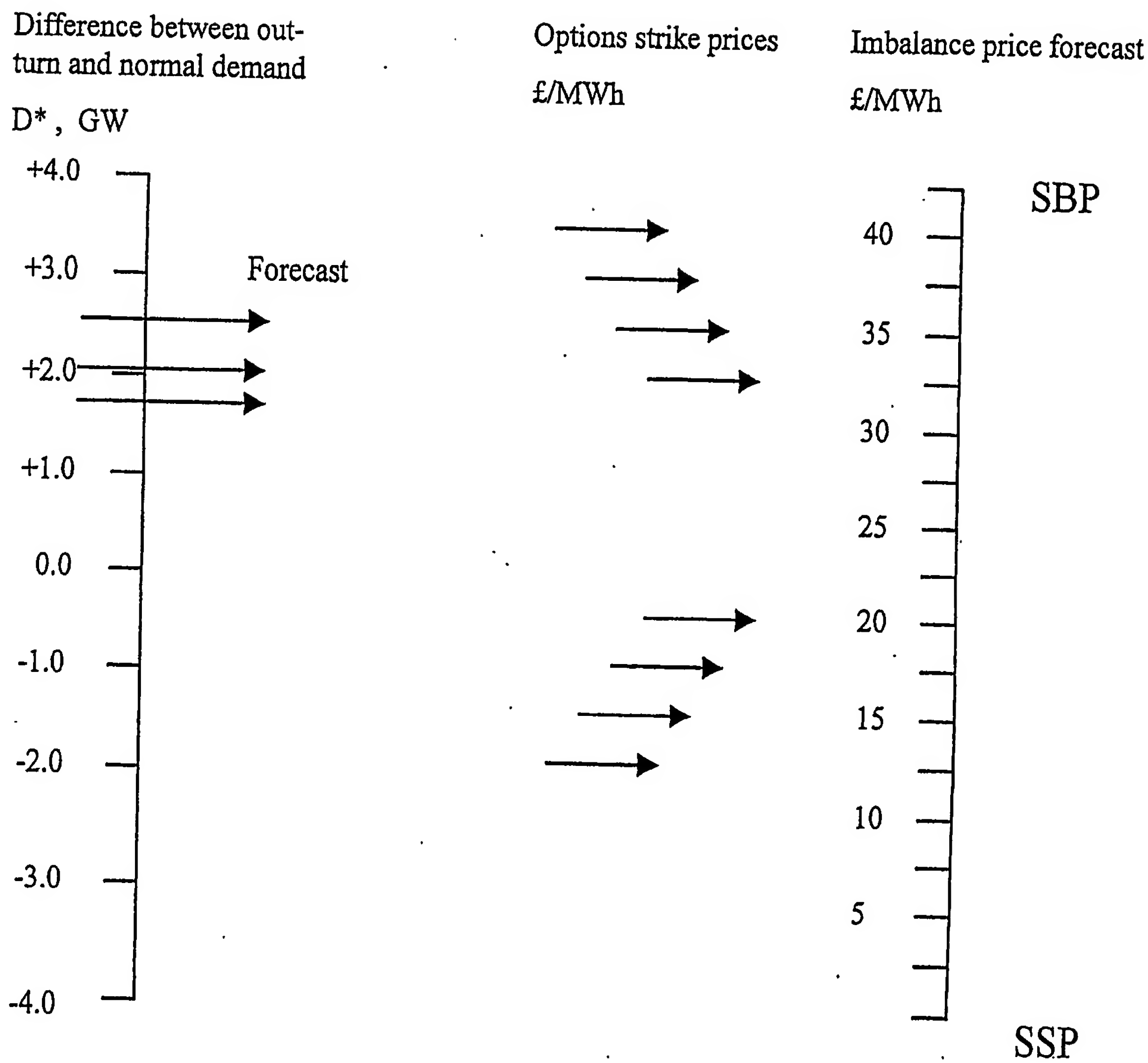


Fig. 4: NDspot Integration - II



4/8

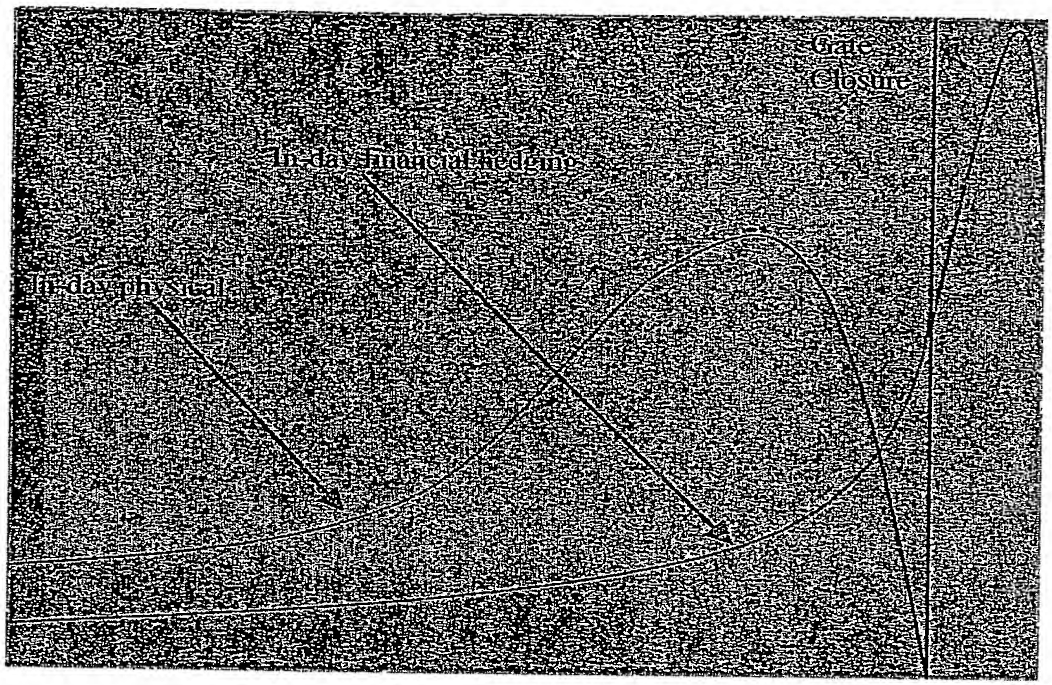
Fig. 5: Financial hedging



6/8

Fig. 6

Trade Volumes, MWh



-24.00 -1.00 0.00

Time to energy consumption

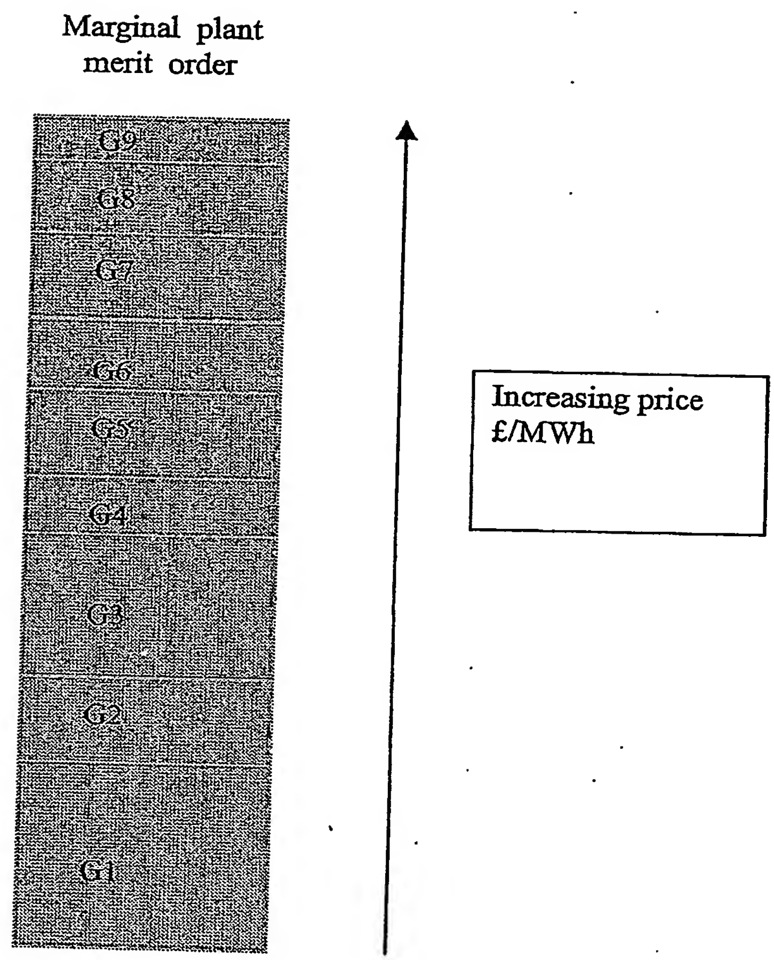

Marginal plant merit order
G9
G8
G7
G6
G5
G4
G3
G2
G1
Increasing price £/MWh

Fig. 7

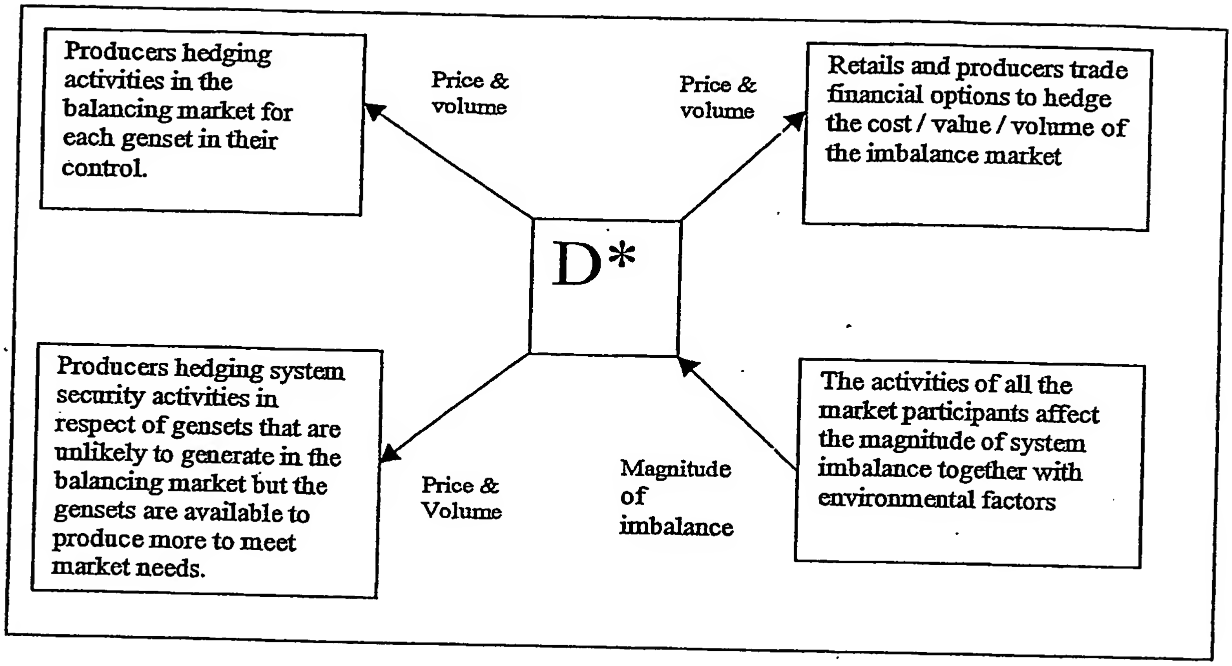


Fig 8

BEST AVAILABLE COPY